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(71) Applicants *(for all designated States except US)*: PEARPOINT LIMITED [GB/GB]; 58 Woolmer Trading Estate, Bordon, Hampshire GU35 9QF (GB). SECRETARY OF STATE FOR DEFENCE [GB/GB]; Whitehall, London SW1A 2HB (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : SEFTON, Alan, Keith [GB/GB]; Rowallan Cottage, Farnham Lane, Haslemere, Surrey GU27 1HE (GB). GALBRAITH, Philip [GB/GB]; 5 Priory Close, Dartford, Kent DA1 2JF (GB).

(74) Agent: GEE & CO.; Chancery House, Chancery Lane, London WC2A 1QU (GB).

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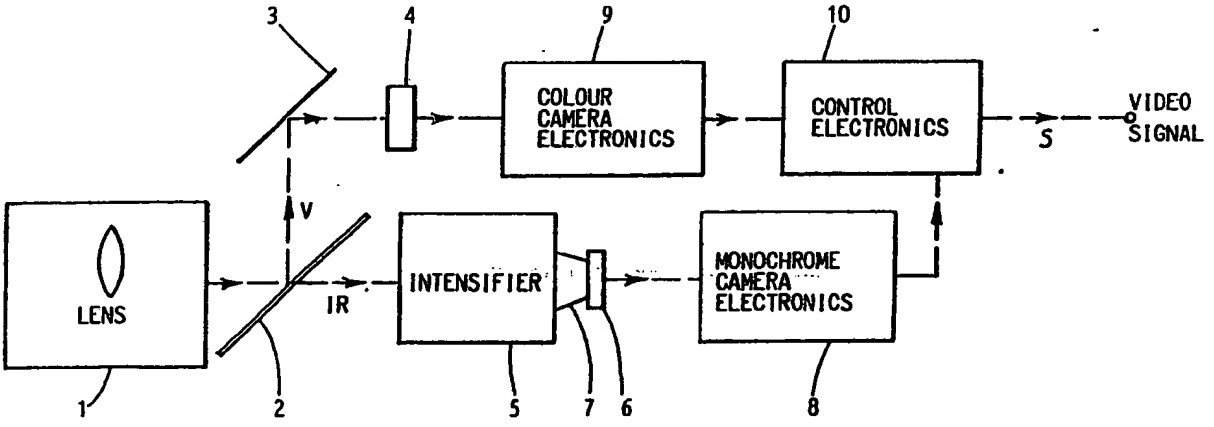

(57) Abstract

A T.V. surveillance camera is disclosed. The camera comprises a lens (1), and electronic means (8, 9, 10) for deriving video signals (S) from images focused by the lens (1) onto image sensors (4, 6). Separating means (2) are provided to (a) separate essentially visible light (V) from the lens (1) and pass that light (V) to a first sensor (4), and (b) separate essentially infra-red light (IR) from the lens (1) and pass that light (IR) to an image intensifier (5) coupled to a second sensor (6). The image intensifier (5) is preferred to be a Gen 3 intensifier. Separation may be effected by means of a dichroic mirror (2) reflecting light below 700 nm and transmitting light above 700 nm, with a reflecting mirror (3) to correct the reversal of the dichroic mirror (2).

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T.V. Surveillance Camera

This invention relates to T.V. cameras intended for use in both daytime and night-time conditions, such as in surveillance operations.

Intensified T.V. cameras inevitably give less-than-perfect pictures during daytime due to the necessity of limiting the light level at the input photocathode of the image intensifier which is required for night-time operations. The poorer picture under daylight conditions (compared to typical daytime-only cameras) may be regarded as the price which must be paid to achieve good night-time performance.

The Mean Time Between Failure of such an intensified camera is governed to a large extent by the life of the image intensifier, and the useful life of an intensifier is inversely related to the photocathode illumination. The average daytime illumination is much higher than the average night-time illumination and, consequently, the major part of the life of the device is used up during the day when the camera is employed continuously.

In recent years, several cameras have been developed which attempt to optimise both night-time and daytime performance by incorporating two complete cameras in a common housing and using a common lens. Change-over between day and night-time operation is achieved by mechanically shifting the daytime imaging sensor and the night-time intensifier/imaging sensor.

It is one object of the present invention to provide combined night-time and day-time cameras which do not require the intensifiers/sensors to be moved mechanically.

The image intensifier technology used in night-time T.V. cameras was originally developed for night-time use in rifle sights and night driving/flying goggles. The early intensifiers (which are still manufactured) use a high voltage to accelerate electrons released from the photo-cathode towards a phosphor screen. The impact of each electron onto the screen releases many photons, and luminous gain of 100x is not untypical. Tubes using this principle are known as First Generation tubes (Gen 1). For night sight use, three tubes may be coupled together to give luminous gains of 50,000 or more, but such a combination is very bulky and unsuitable for use in, for example, goggles and other situations.

Small, light-weight image intensifiers with gains similar to three coupled Gen 1 intensifiers were subsequently developed by the inclusion of a Micro Channel Plate (MCP) which can be thought of as an array of photo-multipliers. The term used to describe this technology is Second Generation (Gen 2). Both Gen 1 and Gen 2 intensifiers use alkali-based photo-cathodes termed S20 and S25, both of which materials can be damaged by exposure to high levels of illumination, even when the devices are unpowered. The S25 multi-alkali photo-cathode is characterised by a better near infra-red (IR) response than the S20 bi-alkali photo-cathode. The spectrum of night-time (star-light) illumination contains a considerable IR component. In quantative terms, the responsivity of the photo-cathode is typically 300 micro-amps per lumen (2856°K source).

Further developments have been made in photocathode technology to obtain better responsivity, and this has resulted in an MCP-based image intensifier with a gallium arsenide photocathode, which is known as Third Generation (Gen 3). A gallium-arsenide photocathode has a responsivity

of typically 1000 micro-amps per lumen (2856 degrees K source), and these intensifiers are fitted with micro channel plates to yield high luminous gains. A feature of a gallium arsenide photocathode is that it has virtually no response below a wavelength of 600m (that is over most of the visible spectrum) but has an excellent response between 600 and 900 nm wavelengths.

The development of small monochrome and colour TV cameras has generated an interest in day/night cameras using a single lens with two internal cameras to give optimum daytime (frequently colour) and intensified night-time performance. These cameras use Gen 2 intensifiers coupled to CCD sensors for night-time use. The change-over from daytime sensor to night-time sensor is achieved mechanically by moving one sensor away from the lens and moving the other to take its place. The change-over time can be quite long, say 15 to 30 seconds, and no picture is available during this time, which can be a serious shortcoming in some covert surveillance situations. Furthermore, mechanical shift can generate sound and virtually all mechanical systems are fallible to a degree.

The broad concept of the present invention is to separate at least a substantial proportion of the IR part of the spectrum of light incoming through the camera lens and pass that proportion to an image intensifier before being sensed, whereas the remaining and largely visible light is sensed by a separate image sensor which may be colour.

According to the present invention, there is provided a T.V. surveillance camera, comprising lens means, and electronic means for deriving video signals from images focused by said lens means onto image sensors, characterised in that separating means are provided to (a) separate essentially visible light from the lens means and pass that light to a first sensor, and (b) separate essentially

IR light from the lens means and pass that light to an image intensifier coupled to a second sensor.

Suitably, separation is effected by means of a dichroic or 'cold' mirror which, ideally, reflects light below about 700 nm and transmits light above about 700 nm. Preferably, said image intensifier comprises a Gen 3 intensifier as hereinbefore defined.

The Gen 3 intensifier has a spectral response which is mainly in the near IR. This property therefore allows a spectrum separation technique to be used, using purely optical means, to pass the IR part to the Gen 3 intensifier and the visible part to the colour (or mono-chrome) camera.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying, diagrammatic drawings in which:

Figure 1 is a layout showing the components of a camera according to the invention;

Figure 2 is a graph illustrating cold-mirror response;

Figure 3 is a graph illustrating Gen 3 cathode response; and

Figure 4 is a graph illustrating night-sky illumination.

Referring to Fig. 1, the scene being imaged by the camera passes through lens 1, a 'cold' mirror 2 which uses dichroic coatings to pass the infra-red (IR) part of the spectrum and to reflect the visible part (V) of the

spectrum. The mirror is set at 45° to the optical path and, consequently, the visible part of the spectrum is turned through 90° to be reflected again by a standard reflecting mirror 3 and focused onto the surface of a daytime CCD sensor 4 which may be mono-chrome or colour. The mirror 3 is provided to correct the reversal of mirror 2 or, alternatively, the second reversal could be achieved electronically. The IR part of the spectrum passes directly to focus onto the photo-cathode of a Gen 3 image intensifier 5.

The physical positions of the image intensifier and daytime sensor along their respective optical axes, are set to maintain a properly focused image.

A monochrome CCD sensor 6 is coupled to the output window of the intensifier 5 by means of a coherent fibre optic bundle or taper 7; as an alternative, lens coupling between the intensifier and the sensor can be used. Electronic assemblies 8 and 9 comprise the circuits for the night-time and daytime sensors, respectively. Circuits 10 select signals received from the sensors 6 and 4, via their respective electronic assemblies, and produce a video signal (S) for the monitor screen (not shown). The circuits 10 also generate control signals to drive the iris of the lens 1 and to set the gain of the intensifier (if fitted with this facility).

It will be appreciated that the above-described combined daytime and night-time camera uses spectrum selecting filters, and preferably Gen 3 intensifiers although Gen 2 and even Gen 1 intensifiers might give acceptable results. Pick-up tube image sensors or related technologies can also be employed, with appropriate modification. It is also possible that the electric assemblies 8 and 9 could be combined or shared.

In operation of the surveillance camera of the invention, continuous viewing can be achieved despite variations in ambient light, including the complete changes between daytime to night-time conditions.

During daytime, the camera lens 1, which may be a lens as used with a 35mm photographic camera, receives high level illumination which is passed on to the cold mirror 2. The visible portion is reflected onto the daytime imaging sensor 4 via the mirror 3. The iris of the lens is set by means of the control circuits 10 to give the optimum light level on the daytime sensor. At this level, the IR portion of the light collected by the lens 1 and which passes through the cold mirror 2 onto the photocathode of the intensifier 5, is at a quite low level and causes little or no long term damage to the photocathode of the intensifier.

The IR portion of light falling on colour imaging sensors must be removed, otherwise the output signal would show an excessively red component due to its appreciable IR response. The cold mirror 2 conveniently performs this function. The transition wavelength of this mirror may be reduced to 650nm or below, without a significant degradation in colour rendition.

As the light level falls towards night-time, there comes a point at which the signal obtained from the daytime sensor is too small to be of use. Intensification is then required, and the intensifier 5 and its associated imaging sensor 6 and electronics 8 can be activated. The intensifier uses only the IR part of the light through the lens 1 which is passed by the cold mirror 2. The control circuits 10 set the intensifier gain (if controllable) and lens iris, to give optimum performance. Under the very lowest light conditions (i.e. below moonlight),

the night-time illumination is substantially in the IR range (see Fig. 4) and little is lost by the filtering out of the visible portion of the spectrum by the cold mirror 2.

CLAIMS

1. A T.V. surveillance camera, comprising lens means, and electronic means for deriving video signals from images focused by said lens means onto image sensors, characterised in that separating means are provided to [a] separate essentially visible light from the lens means and pass that light to a first image sensor,and[b] separate essentially IR light from the lens means and pass that light to an image intensifier coupled to a second image sensor.

2. A T.V. surveillance camera is claimed in Claim 1, in which separation is effected by means of a dichroic mirror.

3. A T.V. surveillance camera as claimed in Claim 2, in which said dichroic mirror reflects light below 700 nm and transmits light above 700 nm.

4. A T.V. surveillance camera as claimed in Claim 2 or Claim 3, in which a reflecting mirror is provided to correct the optical reversal of said dichroic mirror.

5. A T.V. surveillance camera as claimed in Claim 2 or Claim 3, in which electronic means are provided to correct the optical reversal of said dichroic mirror.

6. A T.V. surveillance camera as claimed in any preceding Claim, in which said image intensifier comprises a Gen 3 intensifier (as hereinbefore defined).

7. A T.V. surveillance camera as claimed in any preceding Claim, in which said first image sensor comprises part of a colour camera system.

8. A T.V. surveillance camera as claimed in any preceding

Claim, in which said second image sensor and its said image intensifier comprise parts of a mono-chrome camera system.

9. A T.V. surveillance camera as claimed in Claim 5 or Claim 6, in which said lens means comprises a standard 35 mm camera lens having an iris operated automatically by the electronic assemblies of the camera systems.

10. A T.V. surveillance camera, substantially as hereinbefore described with reference to the accompanying drawings.

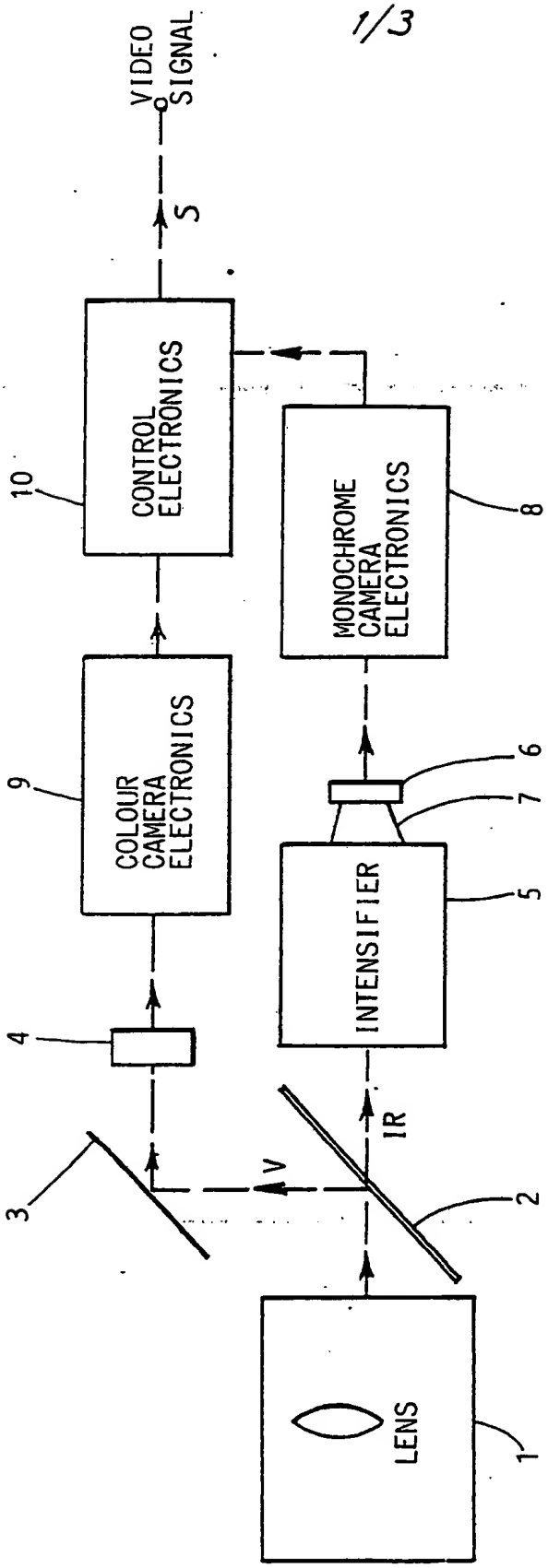
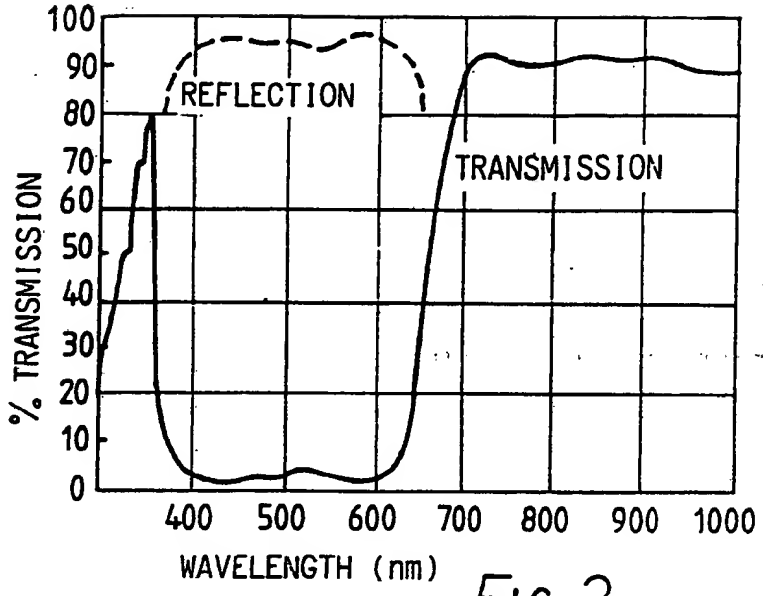

VIDEO SIGNAL
S
CONTROL ELECTRONICS
10
MONOCHROME CAMERA ELECTRONICS
8
COLOUR CAMERA ELECTRONICS
9
6
7
INTENSIFIER
5
4
IR
V
3
2
LENS
1

FIG. 1


100
90
80
70
60
50
40
30
20
10
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REFLECTION
TRANSMISSION
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500
600
700
800
900
1000
WAVELENGTH (nm)

FIG. 2

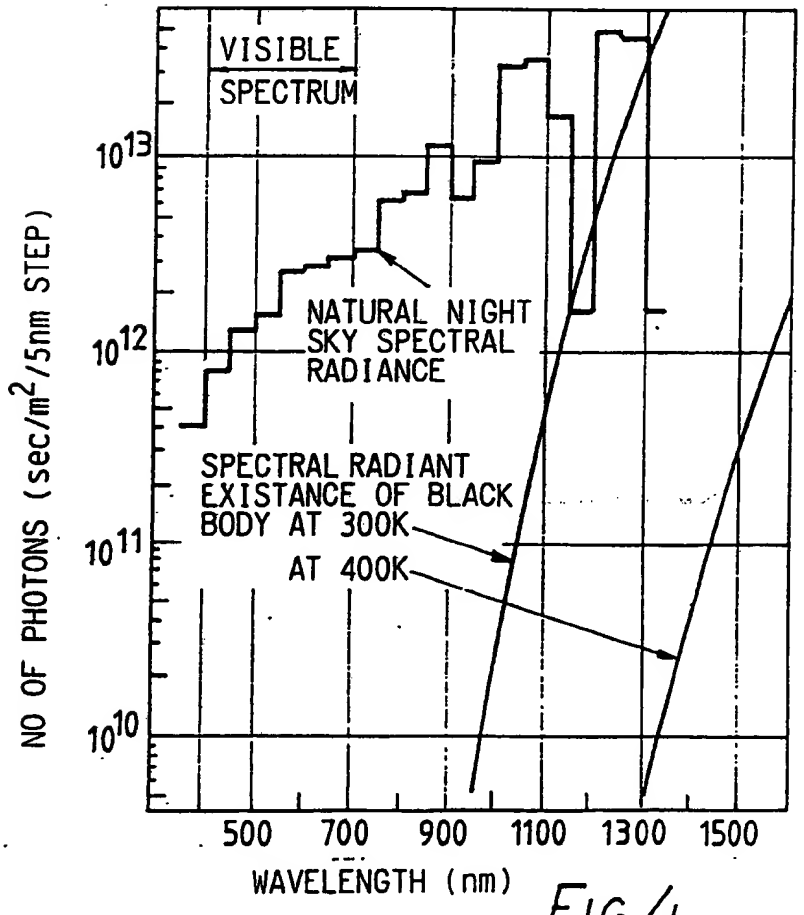
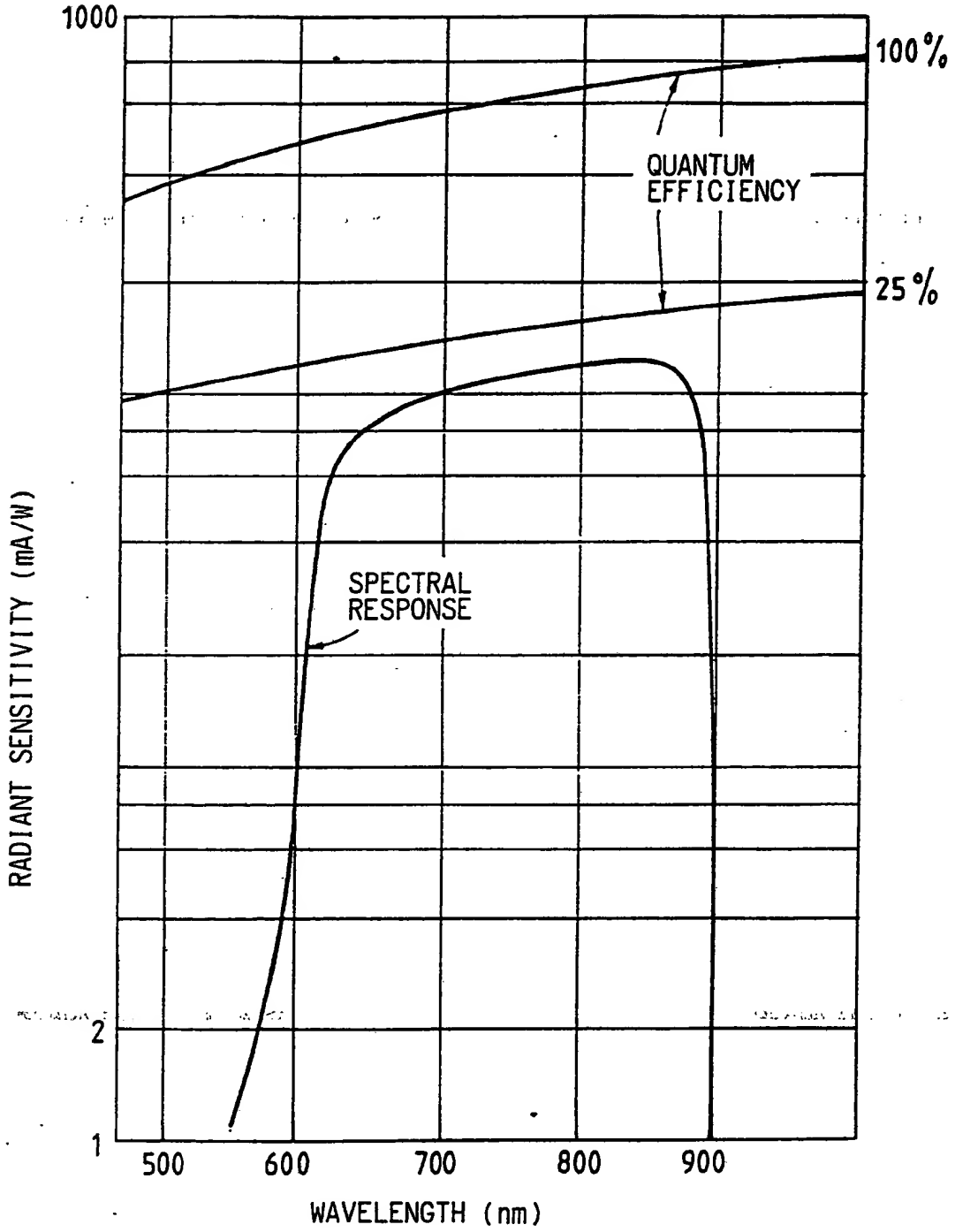

VISIBLE
SPECTRUM
10^{13}
10^{12}
10^{11}
10^{10}
NO OF PHOTONS (sec/m^2/5nm STEP)
NATURAL NIGHT SKY SPECTRAL RADIANCE
SPECTRAL RADIANT EXISTANCE OF BLACK BODY AT 300K
AT 400K
500
700
900
1100
1300
1500
WAVELENGTH (nm)

FIG. 4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100%
QUANTUM EFFICIENCY
25%
SPECTRAL RESPONSE
RADIANT SENSITIVITY (mA/W)
2
1
500
600
700
800
900
WAVELENGTH (nm)

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/01319

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: H 04 N 5/238, H 04 N 5/33

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	H 04 N, G 08 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 4581648 (GANTHER) 8 April 1986, see column 3, line 31 - column 4, line 68; figure 3 --	1,7
A	EP, A, 0176307 (ENGLISH ELECTRIC VALVE CO.) 2 April 1986, see page 4, line 15 - page 8; line 9; figure 2B --	1,2
A	US, A, 3891795 (JOHNSON et al.) 24 June 1975, see column 2, line 24 - column 4, line 17; figure 2	1

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
2nd March 1990	28. 03. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	T.K. WILLIS

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 8901319 SA 32662

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 20/03/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4581648	08-04-86	None	
EP-A- 0176307	02-04-86	DE-A- 3566940	26-01-89
		GB-A,B 2164816	26-03-86
		US-A- 4646140	24-02-87
US-A- 3891795	24-06-75	None	